PHYSICS 312 — Syllabus

Spring 2015

Text: Townsend, *A Modern Approach to Quantum Mechanics* (University Science Books, 2nd Ed. 2012). Note: the 1st edition is perfectly fine as well

Brief review of key concepts and the Hydrogen-atom problem

Addition of Angular Momenta — Clebsch-Gordan Coefficients

Approximation Methods for Bound-State Problems.
- Variational method.
- Perturbation theory (time independent).
- Degenerate case.
- Zeeman effect without spin. Stark effect.

Fine Structure of Hydrogen
- Relativistic kinematic correction.
- Spin-orbit coupling.
- Zeeman effect with spin.

Identical Particles
- Bosons and fermions. Pauli Exclusion Principle.
- Interaction between identical particles — exchange term.

Multielectron Atoms
- Central-field approximation. Shell structure.
- Corrections to central-field approximation. Hund's rules

Molecules
- Ionic and covalent bonds.
- Born-Oppenheimer approximation.
- Vibration and rotation spectra.

Time-Dependent Perturbation Theory
- General formalism. Harmonic case. Long-time limit.
- Fermi's Golden Rule.
- Interactions of atoms with classical electromagnetic fields.
- Adiabatic approximation. Sudden approximation.

Scattering Theory
- Born Approximation.
- Partial waves. Phase shifts. Optical theorem.
- Low-energy scattering: scattering length.

Mixed States and the Density Matrix

Brief introduction to Relativistic Quantum Physics
- Relativistic wave equations. Klein paradox.
- Free field theory. Quantized EM field; photons.